

WHAT IS CLAIMED IS:

1 1. A method for depositing a layer on a substrate in a process
2 chamber, the method comprising:

3 supplying a gaseous mixture to the process chamber, the gaseous
4 mixture comprising a silicon-containing gas, a fluorine-containing gas, an oxygen-
5 containing gas, and a nitrogen-containing gas;

6 providing energy to the gaseous mixture to deposit a nitrogen-containing
7 fluorinated silicate glass layer onto the substrate.

1 2. The method of claim 1 further comprising forming a barrier layer
2 over the nitrogen-containing fluorinated silicate glass layer.

1 3. The method of claim 2 further comprising forming a metal layer
2 over the barrier layer.

1 4. The method of claim 3 wherein the metal layer comprises
2 copper.

1 5. The method of claim 1 wherein the nitrogen-containing gas is
2 selected from the group consisting of N₂, N₂O, NH₃, and NF₃.

1 6. The method of claim 1 wherein the silicon-containing gas
2 comprises TEOS, the fluorine-containing gas comprises SiF₄, and the oxygen-
3 containing gas comprises O₂.

1 7. The method of claim 1 wherein the gaseous mixture further
2 includes an inert gas.

1 8. The method of claim 1 wherein providing energy comprises
2 forming a plasma from the gaseous mixture in the process chamber.

1 9. The method of claim 1 wherein a ratio of a flow rate of the
2 nitrogen-containing gas into the process chamber to a total flow rate of the gaseous
3 mixture into the process chamber is less than about 10%.

1 10. The method of claim 1 wherein the nitrogen-containing
2 fluorinated silicate glass layer has a nitrogen content of less than about 5 at. %.

1 11. The method of claim 10 wherein the nitrogen-containing
2 fluorinated silicate glass layer has a nitrogen content of less than about 1 at. %.

1 12. The method of claim 11 wherein the nitrogen-containing
2 fluorinated silicate glass layer has a nitrogen content of less than about 0.1 at. %.

1 13. The method of claim 12 wherein the nitrogen-containing
2 fluorinated silicate glass layer has a nitrogen content of about 0.03-0.08 at. %.

1 14. The method of claim 1 wherein the nitrogen-containing
2 fluorinated silicate glass layer is formed over a barrier layer.

1 15. The method of claim 14 wherein the barrier layer is formed over
2 a metal layer.

1 16. The method of claim 15 wherein the metal layer comprises
2 copper.

1 17. The method of claim 14 wherein the barrier layer comprises at
2 least one of tantalum and tantalum nitride.

1 18. A method of forming a layer on a substrate in a process chamber,
2 the method comprising:

3 forming a fluorinated silicate glass layer over the substrate;
4 forming a patterned photoresist layer over the fluorinated silicate glass
5 layer;

6 etching the fluorinated silicate glass layer according to the patterned
7 photoresist layer;

8 removing the photoresist layer and substantially simultaneously
9 introducing nitrogen dopants into the fluorinated silicate glass layer by subjecting the
10 photoresist layer and the fluorinated silicate glass layer to a plasma formed from a
11 nitrogen-containing gas.

1 19. The method of claim 18 wherein the nitrogen-containing gas is
2 selected from the group consisting of N₂ and NH₃.

1 20. The method of claim 18 wherein the nitrogen-containing gas
2 comprises at least one of N₂ and NH₃.

1 21. The method of claim 18 wherein the plasma contains no oxygen
2 species.

1 22. The method of claim 18 wherein nitrogen dopants are
2 incorporated into the fluorinated silicate glass layer in a region near a surface of the
3 fluorinated silicate glass layer which is exposed to the plasma formed from the
4 nitrogen-containing gas.

1 23. The method of claim 22 wherein the region near the surface of
2 the fluorinated silicate glass layer has a nitrogen content of less than about 10 at. %.

1 24. The method of claim 23 wherein the region near the surface of
2 the fluorinated silicate glass layer has a nitrogen content of about 1 to about 5 at. %.

1 25. The method of claim 18 further comprising forming a barrier
2 layer over the nitrogen-containing fluorinated silicate glass layer.

1 26. The method of claim 25 wherein the barrier layer comprises at
2 least one of tantalum and tantalum nitride.

1 27. The method of claim 25 further comprising forming a metal layer
2 over the barrier layer.

1 28. The method of claim 27 wherein the metal layer comprises
2 copper.

1 29. A substrate processing system comprising:
2 a housing defining a process chamber;
3 a substrate support configured to support a substrate during substrate
4 processing;

5 a gas delivery system configured to introduce gases into the process
6 chamber, including sources for a silicon-containing gas, a fluorine-containing gas, an
7 oxygen-containing gas, and a nitrogen-containing gas;

8 a plasma generating system;

9 a controller for controlling the plasma generating system, the gas-
10 delivery system, and the pressure-control system; and
11 a memory coupled to the controller, the memory comprising a computer-
12 readable medium having a computer-readable program embodied therein for directing
13 operation of the substrate processing system, the computer-readable program including
14 a first set of instructions to control the gas-delivery system to
15 flow a gaseous mixture containing flows of the silicon-containing gas, the fluorine-
16 containing gas, the nitrogen-containing gas, and the oxygen-containing gas;
17 a second set of instructions to control the plasma generating
18 system to generate a plasma from the gaseous mixture; and
19 a third set of instructions to control the substrate processing system to
20 deposit a nitrogen-containing fluorinated silicate glass layer onto the substrate from the
21 plasma generated from the gaseous mixture.

1 30. The substrate processing system of claim 29 wherein the plasma
2 generating system is operatively coupled to the process chamber for generating an *in*
3 *situ* plasma from the gaseous mixture in the process chamber, and wherein the substrate
4 support is configured to support the substrate in the process chamber during substrate
5 processing.